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The performances of Durum Wheat Yield (*Triticum durum* Desf.) under Tillage Effect in Semi-Arid Environment

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Abstract

Yield performances of durum wheat (*Triticum durum* Desf.) variety Waha were evaluated under effects of crop precedent: fallow and wheat, and tool nature of soil preparation: scarifier, moldboards plow or disks plow, during 2006/2007 growth season. The results showed the advantage, in grain yield, of wheat that crop precedent is fallow relatively to wheat following wheat. Tool effect of tillage soil is related to crop precedent. Indeed, Waha cultivated under fallow tilled with scarifier produced more grain than after wheat. However, proper management of production system improved productivity efficiency in rainfed agriculture. It is focused on soil and water resources conservation.

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Key words: *Triticum durum* Desf., yield, crop precedent, tillage tools of soil

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1. Introduction

The High Plains of Sétif, belonging to the semi-arid bioclimatic stage, are characterized by altitude, cold winters and dry summers. Rainfall and temperatures accused serious variations intra-and inter-annual [1]. This region, which stays cereal by necessity, is confronted to intermittent droughts accentuated during grain filling stage [2]. Unstable climatic conditions affected the level and the regularity of cereal production, rainfed essentially. Water deficit is the main factor reducing the potentiality of wheat yield. Its effects depended on its advent period and the sensibility of growth stage [3, 4]. According to Stewart [3], under semi-arid area, as vapor-pressure deficit increases, maximum evapotranspiration increases, and it requires a greater evapotranspiration level to maintain a given yield level. In semi-arid area, where water is scarce and therefore expensive, an appropriated water management is recommended to improve and to stabilize the yields. Therefore, the conjunctive use of the growing-season rainfall with an applying limited irrigation amounts reduced the risk of insufficient rainfall and improved the response of crop in favourable rainfall year [3]. However, to increase production, outside deficit irrigation and areas expansion, the alternatives are not numerous and limited to the most adequate adoption of technical itinerary, axis especially on managing soil moisture [5, 6]. The deficit irrigation combined to the management water for crop can alleviate climatic risk factors in arid and semi-arid regions, by increasing choices for soil and crop management (Perrier) [7]. The methods which conserved amount of rainfall in soil, increases crop productivity in area deficient on water. Angus et Herwaarden [8] mentioned that water use efficiency is affected by crop management as inputs, tillage and rotations. Soil management practices that involve tillage increase water use efficiency by 25 to 40%, result of the processes of evapotranspiration affected by modifying the available water in the soil profile (Hatfield et al.,) [9]. Crop precedent and soil preparation (fragmentation, periodicity) affect the amount of soil moisture used by crop; this is the basic principle of North African dryland [10]. In this approach, is oriented the aim of this contribution for analyze the effects of crop precedent and soil tillage tool on the productivity response of durum wheat (*triticum durum* Desf.) variety Waha.

2. Material and methods

The experiment was conducted during the 2006/2007 cropping season at the Agricultural Experimental Station of Technical Institute of field Crop (SEA-ITGC), Latitude 36°12'N, Longitude 5°24'E, altitude 1080 m above sea level, situated in the High Plateaus of Sétif, East of Algeria. The soil of experimental plot was characterized by silty-clay texture, calcium carbonate tenor exceeds 35%, basic pH, low organic matter for tilled horizon [2]. Durum wheat used for experiment was Waha, genotype with straw and cycle relatively short compared to local cultivar Mohammed Ben Bachir. The field experiment was arranged in a split plot with four replications. Two variants of crop precedent and three of tillage represented the

treatments studies. Respectively, it distributed: durum wheat, fallow, and soil tilled with scarifier, reversible moldboard plow and with disks plow. The main plots carried the crop precedent and the elementary plots, with dimensions of 10 m x 5 m, carried the soil tillage. Mechanical sowing was realized on december 12, 2006, in density of 300 grains m^{-2} . The control of weeds was applied at tillering stage, by using 12 g ha^{-1} of Granstar [Methyl Triberunon] herbicide mixed with water. Super phosphate 46% with 100 kg ha^{-1} was applied on october 2006 and on february 2007, 70 kg ha^{-1} of urea were spreaded at tillering stage. The measures concerned vegetation height, above ground dry matter accumulated at maturity, grain yield and yield components, noted as described by [4]. The climate data were obtained from the Weather National office (WNO) of Sétif and were analyzed using Microsoft Excel and Cropstat software [11].

3. Results

3.1. Climatic conditions

Cumulative precipitation was of 388,9 mm for the cropping season and for the wheat growth season 326,8 mm (figure 1). The mean air temperature recorded on march was 8,0 °C, that of may reached 16,8 °C, coinciding with stage heading; jellies in active period of vegetation were noted. The growth season was especially characterized by cold and relatively dry winter, and by a soft and rather humid spring (figure 1).

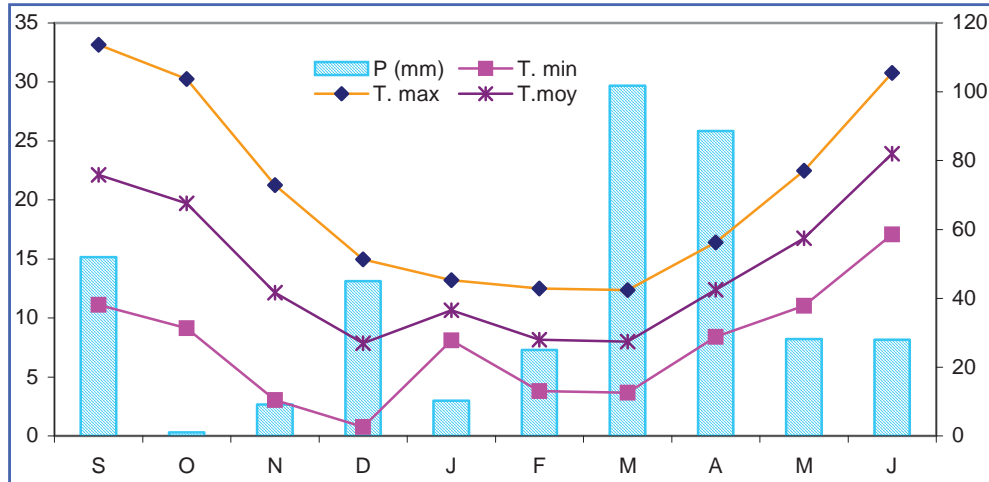


Fig.1. Minimal, maximum and mean temperatures (°C) and monthly rainfall recorded in SEA-ITGC of Sétif during cropping season 2006/2007 (WNO, 2007)

3.2. Effects Analysis of crop precedent and soil tillage tools

The main effects of crop precedent and of soil tillage tools of grain yield, spikes number, krenels number, plant height and of above ground matter dry were significant. On the contrary the effect on the weight of 1000-krenels was not. Interaction was not, either, significant for the spikes number and for above ground matter dry (table 1). The dimension of the mean squares of variation revealed the preponderance of the crop precedent relatively to that soil tillage tool. This was also indicated by the study of mean values of the measured variables, which showed that difference between the both precedents were broadly more important than that observed by soil tillage (Table 2). The analysis of interaction indicated that penalized effect of the wheat precedent, on grain yield of wheat which followed, was reduced when the soil tillage was realized with scarifier. On the other hand, advantageous effect of tilled fallow precedent, on grain yield of wheat which follows, was minimized when deep tillage was accomplished with the disks plow (Figure 2). These effects owed to interaction between crop precedent and soil tillage tool were explained broadly by the both principal components of yield, the spikes per m² and the krenels by spike (Figure 3).

Table 1. Mean squares of the analysis of variance of the variables measured on Waha variety conducted under two precedents crop combined to three soil tillage modes, during cropping season 2006/2007

Sources	Df	Gy	SN	KNS	TKW	PHT	DM
Total	23	171.0	1143.5	12.5	1.6	22.0	442.7
Precedent (P)	1	3608.1**	14016.7**	112.7**	3.4 ^{ns}	442.1**	9188.5**
Residual a	6	3.9	388.6	2.9	0.3	1.5	23.3
Tools (T)	2	70.0**	3070.2*	23.0*	0.5 ^{ns}	19.5*	293.5**
Tx P	2	51.6**	8.1 ^{ns}	48.0**	6.8*	3.8*	38.8 ^{ns}
Residual b	9	5.1	388.1	1.3	1.2	0.5	17.6

Gy= Grain yield (qha⁻¹), SN= Spikes number (m²), KNS= krenels number by spike, TKW= 1000-krenel weight (g), PHT= Plant height (cm), DM= Above ground dry matter (qha⁻¹).

ns, *, ** = no significant effect and significant effect at 5%, 1% levels respectively

Under scarifier, the produced above ground dry matter was 104.9 qha⁻¹ and the real gain attained 12.0 qha⁻¹ and 7.2 qha⁻¹ compared to disks and moldboards plows. The soil tillage with scarifier valorized Waha productivity for the grain. The crop precedent affected the yield and its components. Therefore, Waha cultivated under fallow realized more spikes and krenels than after wheat precedent. The thatch height was very affected by crop precedent, 92.8 cm measured on fallow and 84.2 cm under precedent wheat.

Table 2. Mean values of the measured variables of Waha conducted under two crop precedents combined to three soil tillage modes, during cropping season 2006/2007

Precedent	Tool	Gy	SN	NKS	TKW	PHT	DM
Principal effect precedent							
Fallow		50.2	423.5	32.0	43.5	92.8	118.1
Wheat		25.7	275.2	23.6	43.1	84.2	78.9
LSD5%		1.9	19.7	1.7	0.55	1.2	4.8
Principal Effect tools							
	MP	37.1	333.5	27.2	43.5	88.5	97.7
	DP	35.5	325.0	26.6	43.7	86.8	92.9
	SC	41.2	393.5	30.0	43.2	90.0	104.9
LSD5%		3.6	31.5	1.8	1.8	1.1	6.7
Interaction precedent x tools							
Fallow	MP	52.3	424.0	32.5	44.6	92.7	119.8
Fallow	DP	45.9	380.0	31.5	43.1	90.5	111.4
Fallow	SC	52.4	467.0	31.5	43.9	95.0	123.1
Wheat	MP	22.0	237.0	22.0	42.4	84.2	75.6
Wheat	DP	25.0	270.0	21.7	44.4	83.2	74.4
Wheat	SC	30.0	320.0	28.5	42.5	85.0	86.8
LSD5%		3.6	31.5	1.8	1.8	1.1	6.7

Gy= Grain yield (qha^{-1}), SN= Spikes number (m^2), KNS= krenels number by spike, TKW= 1000-krenel weight (g), PHT= Plant height (cm), DM= Above ground dry matter (qha^{-1}), SC= Scarifier, DP= Disks Plow, MP= Moldboards plow

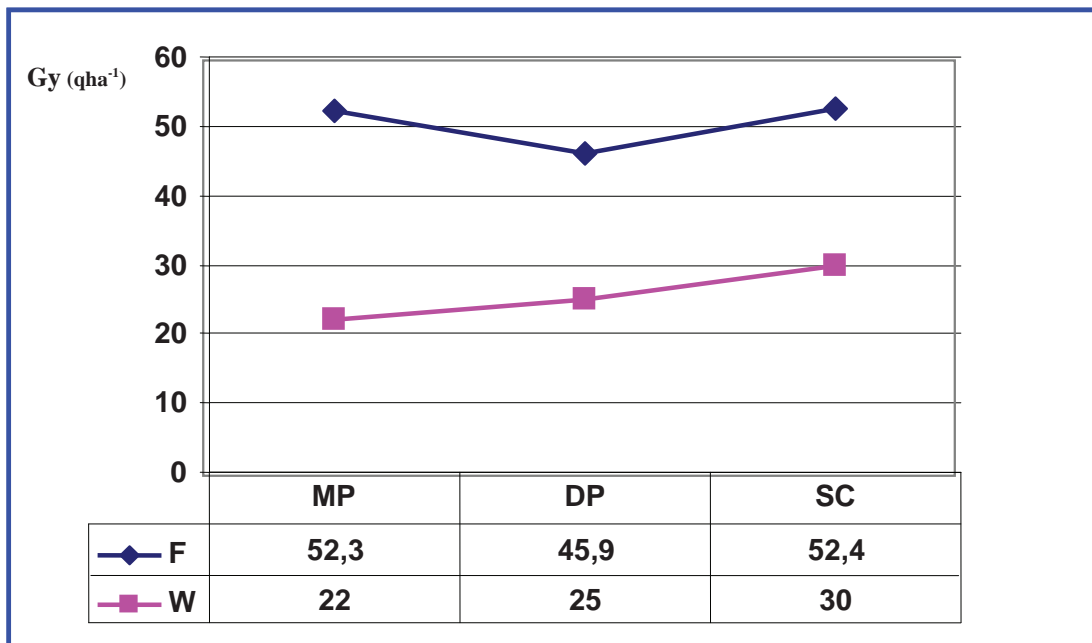


Fig.2. Grain yield variation realized by Waha cultivated under wheat precedent (W) or fallow (F), tilled with scarifier (SC), disks or moldboards plows (DP, MP) during cropping season 2006/2007

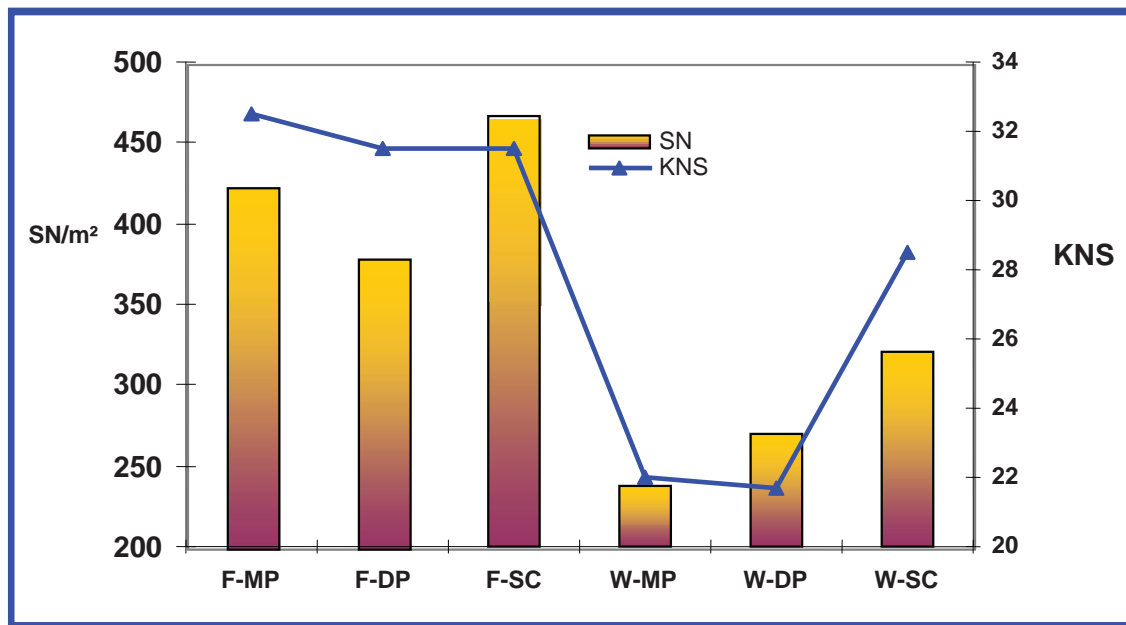


Fig.3. Mean values of the measured spikes number (m^{-2}) (SN m^{-2}) and krenels number by spike (KNS) realized by Waha cultivated under wheat precedent (W) or fallow (F), tilled with scarifier (SC), disks or moldboards plows (DP, MP), 2006/2007 cropping season

3.3. Discussion

The better performance of Waha for its characters measured to produce more grain under scarifier was explained by the fact that scarifier ensured a coarse crumbling and a soil homogenization, disturbing less the soil and consequently, the water evaporation from soil was reduced. Eliard [12] signed that the action principle of scarifier was realized through the reduction of the earth lumps under the teeth action. These elements were interesting in rainfed condition to ensure for the roots plant a quantity of limited water for improving wheat productivity. On the other hand, the principles of disks and of moldboards plows were centered on the reversal of land strip on a depth of 30 cm. This operation generated the soil structure destruction and increased water evaporation on depth horizons, thus reducing the structural stability and the soil fertility (Prévost) [13]. The soil tillage was the first measure to taken to fight against the soil degradation for water and organic matter preservation, for aggregates reconstitution, for water saving and for reducing erosion effects. Gréco [14] considered that soil tillage is sometimes harmful. The author advised that the antierosive cultural practices adapted to the various speculations determined on preliminary the effectiveness of soil defense practical against erosion [14]. This approach supported the goal of this study. In rainfed agriculture, Araus [15] noted that the tillage practices constituted an amelioration alternative by preserving water in soil. In fact, these practices present an advantage during

crop year variations to reducing the climate effect. According to Stewart [3] the key to successful dryland farming in semi-arid regions is using systems and practices that can take advantage of the favorable years. The soil mode tillage by scarifier disturbed less the soil, thus ensuring a homogeneous distribution of moisture on the level of cultural profile. Therefore, the plant used with regulated manner the available water at the level of the roots zone, enhancing the wheat productivity (Chennafi; Hannachi et Fellahi) [16, 17]. Nielsen *et al.*, [18] reported that the water availability for crop at the critical stage depended on the soil water content at the time of its plantation and it depended on the soil tillage, on the crop residues affecting the efficiency of precipitation storage. Indeed, water use efficiency is a component of the crop resistance to water stress, it is determinant for yield (Blum) [19].

The significant effect of crop precedent for the measured characters indicated the superiority of the productive capacity of Waha under fallow than under after wheat. This difference was related to the soil exhausting effects of the continue crop for the same plant where the roots explored the same horizons. Consequently, the soil will become less resistant to the effects of the climate elements (Gréco) [14]. Campbell *et al.*, [20] explained the better results produced by crops under fallow by water conservation at sowing of 43 mm on 120 cm of soil [16,17]. These consequences were related to the introduced fallow in the rotation system in semi-arid zones and which improved the soil fertility indices, by the intermediary improved, and stabilized the production (Sabert et Merabet) [21]. Maintaining crop residue on the soil surface include reduced soil loss as a result of water or wind erosion as well as increased water infiltration and soil water storage efficiency (Drew *et al.*,) [22].

The interaction tool x cultural precedent significant marked the variation of the measured characters according to the soil tillage depending to crop precedent. The scarifier valorized the expression of Waha to produce more grain under fallow and wheat precedents. However, under fallow the soil mode tillage for grain yield amelioration followed the expression SC>MP>DP, but for wheat after wheat, it was concretized by SC>DP>MP. The effect of wheat precedent to realize more grain yield for wheat, which follows, was favored by the soil tillage with scarifier. On the other hand, the tillage with disks plough reduced the beneficial effect of fallow precedent. The explanations of these effects due to the interaction of the crop precedent under the soil tillage mode were dependents to the spikes numbers per m² and to the krenels number per spike. Indeed, Waha cultivated after wheat tilled with scarifier engendered more spikes and a superior fertility than those obtained under disks plow or moldboards plow. However, the tillage with disks plough which reduced the beneficial effect of fallow, devaluing the productive expression of Waha for the spikes numbers and its fertility.

These differential results of tillage soil effects of tools associated to the crop precedent were described by the principle action of tool and to advantage of crop precedent. These results corroborated those presented by Chennafi et al., [23]. The effect of soil tillage tools was associated to the surface horizon macroporosity, the pores morphological space and with the porosity distribution (Kribaa et al.,) [24]. The soil tillage influenced the evaporation process considered component of the water loss from soil that its structure was modified by tillage, through its effects on the physical properties of soil surface and on the tilled layer (Mrabet) [25]. In semi-arid regions, the use of genotype with better performance with the capacity to avoid the late season stress associated to an appropriated management system that can contribute to the better use of rainfall is the objective in rainfed agriculture.

Conclusion

In semi-arid conditions, rainfed agriculture must be surrounded by an appropriate agricultural management practices adapted to soil, climate and crop. The feasibility of these practices is conceived by the plant environment governorship. Turner [26] reported that before considering agronomic options for the improvement of yield and rainfall use efficiency in dryland farming systems, it is necessary to know the environmental conditions under which the dryland crops are grown and the likely incidences of water shortage. In fact, the agricultural production is dependent on the quality of the first 100 cm of the soil surface, on the crop relevance and the cultural practices management (Nagarajan) [27]. The reduced tillage of soil and the crop residues under soil increase the storage efficiency of precipitation water (Mrabet; Turner; Norwood) [25, 26, 28]. In this approach, the results of the present study were evaluated. In effect, the crop precedent and the soil tillage tool increased the performances of durum wheat to produce more grain yield. The productivity of Waha cultivated under fallow was higher than that cultivated after wheat. The soil tillage with scarifier was more efficient. The differential valorization of wheat productivity resulted from the soil valorization capacity for water rain under the effect of crop precedent combined to soil tillage modes. The soils hydrous compartments were different under crop precedent combined to soil tillage tools. In semi-arid environment, the productivity of durum wheat resulted through preservation of limited water quantity at efficient crop stages on water. The formulation of rural renewal system is related to techniques that tend to realize stable improvement of agricultural production with an environmental preservation of water and soil resources.

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